Special Publication No. 13-13

Summary of the Interagency Crab Research Meeting Held December 14–16, 2011

by

Joel Webb

July 2013

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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by
Joel Webb
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

July 2013

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Joel Webb,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
Headquarters Office, 1255 W. 8th St. P.O. Box 115526, Juneau, AK USA

This document should be cited as:
Webb, J. B. 2013. Summary of the interagency crab research meeting held December 14–16, 2011. Alaska Department of Fish and Game, Special Publication No. 13-13, Anchorage.

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PURPOSE

This report summarizes the eighteenth annual interagency crab research meeting, held December 14–16, 2011, in Anchorage at the Hotel Captain Cook. The interagency crab meetings began in 1993 and are held annually as prescribed in the *State/Federal Action Plan for Management of Commercial King and Tanner Crab Fisheries* (revised March, 2006, and available from the author) an agreement between the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G). This meeting continued the tradition of providing an informal opportunity for researchers from each of the active crab research centers to present their work on Alaskan crab species among peers. The meeting included a special session on survey techniques for crab stocks in Alaska, contributors were asked to review current practices and summarize key sources of uncertainty in survey design and implementation.

Key Words: Alaska crab research, red king crab, blue king crab, Dungeness crab, golden king crab, Tanner crab, snow crab, crab surveys, alternative survey methods, trawl survey, pot survey

PARTICIPANTS

The 2011 meeting was attended by approximately 60 participants representing ADF&G, NMFS, The School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (UAF), and University of Alaska Southeast (UAS). A list of participants and contact information is included in Appendix A.

PRELIMINARIES

The meeting was jointly chaired by Doug Woodby and Russ Nelson and audiovisual operations were run by Joel Webb. Following introductions and welcoming remarks, the draft agenda (Appendix B) was adopted without change.

SUMMARY OF PRESENTATIONS

The order of presentations followed the agenda (Appendix B), which was organized roughly by contributing group, University of Alaska, NMFS, and ADF&G.

SPECIAL TOPIC: CRAB SURVEYS IN ALASKA–CURRENT AND FUTURE PRACTICE

From sensors to platforms, from data to information—How technology can help in benthic surveys for fisheries related activities

Dr. Hanumant Singh, Woods Hole Oceanographic Institution, Woods Hole, MA

There has been substantial progress in the development of autonomous underwater vehicles (AUVs) as an effective tool for collection for data in the marine environment. A variety of sensors and platforms are now available which can be optimized for the study objective. Key advancements include operational capability, navigational sensors, optical sensors, and data storage and processing. The SeaBEd AUV is one example of a flexible data collection platform. It can be shipped to a location, assembled in less than one day, and deployed from vessels of a wide range of sizes including much smaller vessels than those typically used for oceanographic or fisheries surveys. The SEAbed AUV uses bottom-sensing sonar and transponders to maintain position with high accuracy and has been used for surveys of demersal fishes in rocky, high-relief habitats inaccessible by other methods. Optical sensors for fisheries data collection can include multiple cameras in varying configurations with the ability to capture varying parts of the light spectrum. Combinations of these techniques can be used to address challenges of resolution, contrast, and camera avoidance for the census and photogrammetry of the target organisms. Processing images from optical surveys is labor intensive due to the large number of images ($>10^4$) collected but advances in software show promise for automation of some aspects of this task**.** Towed systems can provide some of the same capabilities, but AUVs are capable of accessing

environments (e.g., under ice) where other gears are inoperable and frequently have advantages of reduced cost in terms of vessel-size and days-at-sea requirements.

The eastern Bering Sea continental shelf bottom trawl survey: focus on crab

Bob Foy, Claire Armistead, and Jan Haaga, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK

The National Marine Fisheries Service eastern Bering Sea bottom trawl survey provides fishery independent information on abundance, distribution, and biological data which supports the assessment and management of fisheries for red king, blue king, Tanner, and snow crab in the region. Standard survey sampling includes 396 stations on a standard 20 nm survey grid. Multiple factors challenge estimation of crab abundance or contribute to survey uncertainty including 1) untrawlable bottom types; 2) availability of crab to the survey; 2) variability in crab density at varying spatial scales; 3) difficulty in identification of *Chionoecetes* hybrids; 4) effects of stratification on abundance estimates; 5) measurement error due to subsampling; 6) environmental variability; and 7) environmental effects which affect crab distribution, survival, and ecosystem structure. Alternatives to address these uncertainties and challenges include development of acoustic or optical survey techniques, adaptive survey designs, genetic identification of species, geostatistical modeling techniques, automation of biological data collection, and ecosystem modeling or process studies.

Norton Sound red king crab overview

Toshihide "Hamachan" Hamazaki, ADF&G, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Anchorage, AK

Jenefer Bell, ADF&G, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Nome, AK

The Norton Sound king crab stock is the northernmost stock in Alaska to support a commercial fishery. Information on habitat, distribution, and movement is largely unknown, but crab undergo a clear seasonal shift in distribution from inshore to offshore. The stock is targeted by a summer small boat fishery, which accounts for the majority of the catch, and pots are also set through the ice in winter. Fishery independent assessment information includes a triennial trawl survey which covers most of the stock distribution and a winter (through the ice) pot survey which occurs in a limited spatial area. The spatial distribution of the harvest has shifted dramatically through time from western to eastern Norton Sound since the early 1990s. A number of factors present challenges and uncertainties to management of the fishery. Preseason biomass estimates have tended to overestimate abundance leading to retrospective harvest rates above target levels. Limitations to surveys include the frequency of the summer survey, untrawlable habitat, and vessel availability. There is also difficulty in obtaining biological and distribution information during mating, spawning, and larval release. Fishery management would benefit from improved information life history, development, movement, and female reproductive parameters and better estimates of abundance from annual trawl surveys and eastward expansion of winter pot surveys.

Southeast Alaska crab stock assessment

Gretchen H. Bishop, ADF&G, Division of Commercial Fisheries, Southeast Region, Douglas, AK

Fishery management measures for Tanner and red king crab stocks in Southeast Alaska include a minimum biomass threshold for opening of the fishery, guideline harvest levels by district for red king, and adjustments in season length as a function of biomass and effort for Tanner crab. Fishery independent data on stock status is gathered during pot surveys and harvest data is available from fish tickets, dockside sampling of landed catch, and vessel logbooks. Red king crab fishery and

survey data is translated into a biomass estimate using a catch-survey analysis model. A large male exploitation rate which varies with stock status relative to long-term trends is used to determine the guideline harvest level by district with an expansion to unsurveyed areas. Tanner harvest is determined by changes in season length (days fishing) based on relationships between the number of pots registered for the fishery and threshold values of mature male biomass. Sources of error or uncertainly in management can be separated into process and observation error. Process error may include the biological threshold and sustainable harvest rates, expansion for unsurveyed areas, and the assumptions of constant natural mortality and growth rates. Sources of possible observation error include noncommercial harvest estimates for red king crab; whether survey effort is sufficient to index abundance; changes in crab distribution between the survey and fishery; and possible variation in survey catchability (q) with bycatch, environmental factors, or crab density. Observation error is being addressed through an ongoing study to determine independent estimates of red king crab population size and survey power analysis. Further research which could improve management would be better accounting of noncommercial harvest and enhanced understanding of stock-specific movement, habitat association, natural mortality, and growth.

Overview of the ADF&G central region crab survey methods and Tanner crab, *Chionoecetes bairdi*, research update

Rich Gustafson, ADF&G, Division of Commercial Fisheries, Homer, AK

A variety of survey gear types (pot, large mesh trawl, small mesh trawl, and dredge) are used to determine the distribution, biomass, and population structure of shellfish and groundfish in lower Cook Inlet and Prince William Sound. Pot surveys have been conducted for both golden king crab and Dungeness crab in Prince William Sound and Dungeness crab in lower Cook Inlet. Both of these fisheries are closed and surveys have been conducted intermittently to evaluate resource status. Ancillary information on stock status is taken from bycatch in other fisheries and trawl survey information. A large-mesh trawl survey targeting Tanner crab and other commercially important groundfish and invertebrates is also conducted annually with stations in lower Cook Inlet and Prince William Sound. Point estimates of area-swept abundance of Tanner crab relative to threshold values are used in management to determine fishery opening/closure and harvest levels. Uncertainties associated with surveys and management include large differences in male size at maturity estimated from chela height and carapace width among locations and variability in catchability with net performance. Adverse weather condition and derelict pot gear also impact trawl survey performance. An ongoing study of Tanner crab catch rates between counts from video estimated from video and a scallop dredge is an example of alternative approaches to abundance estimation based only on trawl survey data.

Westward region bottom trawl survey of crab and groundfish

Kally Spalinger, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, AK

Crab and groundfish resources in the Kodiak Island, Chignik, South Peninsula, and Eastern Aleutian management districts are surveyed annually by bottom trawl. This trawl survey uses a standard 400-mesh eastern otter trawl and is conducted from the R/V *Resolution*. The number and biological data including sex, size, and female reproductive condition are recorded for commercially important crab observed in survey catches. These are used to generate area-swept abundance estimates. Area-swept indices of abundance are calculated under assumptions of constant catchability and net width and uniform distribution of crab within the survey station. The survey appears to effectively index the abundance of Tanner crab with size-frequency distributions from consecutive years tracking the growth of large cohorts from juvenile to adult stages. Indices

of abundance are translated into harvest levels for each management section using multiple criteria. Minimum stock size thresholds must be met for fishing to occur, harvest rates are scaled to the stock status relative to long-term averages, and harvest rates are capped by a maximum allowable rate for legal males. Several factors indicate that the robustness of abundance estimates may vary among areas. The fishery performance has routinely met expectations in the eastside Kodiak section, but underperformed in the northeast section. The size-frequency distributions of legal-size males observed in the survey also differ from those observed in commercial landings in the northeast section.

Mapping Tanner crab habitat in the Kodiak area of the Gulf of Alaska

Carrie Worton, David Barnard, Gregg Rosenkranz, and Philip Tschersich, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, AK

Christian de Moustier, Heat, Light, and Sound Research, Inc., La Jolla, CA

Abundance of Tanner crab in the Kodiak area is estimated by area-swept methods. Inconsistent results in fishery performance have suggested that the assumption of uniform density crab throughout a survey station may be problematic. A research project has been designed to address this uncertainty. This project will involve collection of acoustic data on benthic habitat and digital imagery of the seafloor and benthic sealife for development of habitat maps to improve Tanner crab stock assessment. High-resolution digital imagery and acoustic data will be collected concurrently using the ADF&G CamSled and a multibeam acoustic system operated from the ADF&G Westward region research vessel the R/V *Resolution*. Cross-referencing of these data sources will allow evaluation of habitat associations between Tanner crab of various life history stages and benthic habitat types and quantification of various habitat types within the areas surveyed. These results will have direct application for the evaluation of the assumption of uniform density within survey stations and the impact on Tanner crab abundance estimation.

Westward region king crab pot surveys

Vicki Vanek, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, AK

Four pot surveys targeting red, blue, and golden king crab have been conducted with varying frequency in the Bering Sea/Aleutian Islands region. The St. Matthew Island blue king crab stock has been surveyed triennially singe 1995. The Pribilof Islands blue and red king crab stocks have been surveyed triennially since 2003, Aleutian Islands golden king crab were surveyed triennially from 1997 to 2006 and a surveys of red king crab at Petrel Bank were conducted in 2006 and 2009. The St. Matthew Island and Pribilof Islands surveys supplement stocks with limited trawl survey coverage while the Aleutian Islands and Petrel Bank surveys provide the only fishery independent data on stock status for these stocks. Objectives of these surveys are to provide an index of relative abundance by life stage and sex for the target species, determine spatial distributions, and provide a platform for tag–recapture studies of movement and mortality. Strengths of the pot survey approach include the ability to survey untrawlable habitat, high spatial density of sampling relative to trawl surveys, and deploying instruments for collection of data on the physical environment. Uncertainties and challenges confronting pot surveys include the sparse temporal distribution of sampling (triennial), assumptions regarding the proportionality of CPUE to abundance, and the availability of commercial boats to conduct surveys in remote locations in a cost-effective manner.

CONTRIBUTED TALKS

Metabolic physiology of snow crab from the eastern Bering Sea: Role of eyestalks during cold exposure

Sherry Tamone, UAS, Biology Department, Juneau, AK

Metabolism and molting in crustaceans is controlled by hormones secreted by organs in the eyestalks. Freezing temperatures are common during the fishing season for snow crab in the eastern Bering Sea and thermodynamic modeling has suggested that crab eyestalks were particularly vulnerable to freezing. Controlled laboratory experiments were carried out to examine the effects of varying levels of eyestalk freezing exposure on metabolism and circulating glucose concentration. Preliminary results suggested that direct freezing of the eyestalks (using freezing gas) and prolonged periods at freezing temperatures (>10 min) were likely to impact metabolism versus controls. Further investigation will compare glycogen levels in tissues and more refined measures of metabolism among treatment groups.

Predicting the distribution and ecological niche of unexploited snow crab populations

Sarah Hardy, UAF, School of Fisheries and Ocean Sciences, Fairbanks, AK

Recent surveys have investigated the abundance and distribution of snow in the northern Bering Sea but the spatiotemporal distribution of sampling and knowledge of the factors shaping the geographic distribution remain limited. To address these gaps in understanding survey data on snow crab was integrated with data on the physical (depth, sea surface temperature, salinity, sea ice, sediment type) and biological (surface productivity, benthic productivity, infaunal biomass) environment in a spatially explicit framework. Three multivariate quantitative methods were used to examine association between these variables and snow crab presence/absence and biomass. Ensemble results suggested that water mass characteristics (nutrient concentration, chlorophyll content, and temperature) and infaunal biomass were important factors shaping the snow crab presence and biomass. These results provide insight for future survey design and formation of testable hypotheses.

Methyl farnesoate in *Chinooecetes opilio*: not your everyday gonadotropic hormone

Molly Zaleski, UAF, School of Fisheries and Ocean Sciences, Juneau, AK

Snow crab have complex reproductive biology with adolescent males producing sperm and potentially mating both before the terminal molt to adulthood. Determining whether adolescent males participate in mating and whether molting compromises male mating potential is a priority research issues since mature male biomass is used as an index of reproductive potential for fishery management. Previous studies have suggested that increased levels of the hormone methyl farnesoate (MF) are associated with increased gonadosomatic index (GSI) in crab species with biology similar to that of snow crab. Nearly 300 male snow crab were collected from 2008 to 2010 from the eastern Bering Sea and GSI was determined for each individual. The concentration of MF in snow crab hemolymph was quantified by high performance liquid chromatography for a subset of these individuals. Significantly higher GSI levels were observed for oldshell (at least one year past the terminal molt) adult males than adolescent newshell, adolescent oldshell, or newshell adult males, but MF levels while variable were generally lower for oldshell males. The disparity in this result with published descriptions may be due to MF functioning to a greater extent as a juvenile-like (growth stimulating) hormone in snow crab versus other species.

In situ predation and behavioral plasticity of juvenile red king crabs (*Paralithodes camtschaticus*)

Ben Daly, UAF, School of Fisheries and Ocean Sciences, Seward, AK

Predation is an important factor structuring marine populations particularly early in life. Crabs and lobsters use many predator defensive and avoidance strategies to reduce detection or improve probability of survival once detected. We evaluated predation rates and predator response behaviors for red king crab, a commercially valuable species in Alaska. A combination of *in situ* tethering monitored by video and controlled laboratory experiments with conditioning followed by exposure to fish predators were used to investigate predation and behavioral responses for early instar juvenile red king crabs. Survival rates were similar among juveniles (<4 mm carapace width) of two sizes classes during summer and autumn. Demersal fishes were frequent predators, but surprisingly, tethered juveniles were most frequently consumed by hermit crabs. Laboratory experiments involved several levels of exposure (no cues, visual/chemical cues, visual/chemical/direct contact cues) of juvenile crabs to a fish predator (halibut) followed by predation trials. Crabs with complete predator exposure had higher survival compared to naïve crabs. Crabs with limited and complete predator exposure had higher initial crypsis, and both naïve and conditioned crabs increased crypsis by the end of the experiment. The results of this study suggest that juvenile red king crab are susceptible to predation by a variety of predators *in situ* and that exposing juveniles to predators in the hatchery prior to release may enhance predator avoidance and allow quick adaptation to the natural environment.

Effects of ocean acidification on larval development of Dungeness crab

Raphaelle Descoteaux, UAF, School of Fisheries and Ocean Sciences, Fairbanks, AK

Increased concentrations of atmospheric carbon dioxide have result in increased seawater carbon dioxide and decreased seawater pH. Decreased seawater pH can negatively impact survival, growth, and physiology of marine organisms. Initial laboratory trials evaluated the potential impacts of seawater acidification on larval Dungeness crab. Newly hatched zoeae were collected and reared at three levels of seawater pH ranging from 7.5 to 8.1 (ambient). Zoeal mortality approached 100% for all treatments at two weeks without evident treatment effects. However, a significant decrease in rostro-dorsal length was observed for zoeae held at the lowest level of pH versus the other treatments. These results suggest that seawater pH may have affected zoeal growth or condition, a pattern that will be further explored by evaluation of zoeal weights and calcification.

Are all eggs equal? Maternal effects on embryo quality in the snow crab, *Chionoecetes opilio*

Joel Webb, UAF, School of Fisheries and Ocean Sciences, Juneau, Alaska

Variation in embryo quality associated with maternal effects, including size and age, can be linked with larval characteristics and survival in some marine fish and invertebrates. Females with intermediate shell ages and large sizes have higher fecundity than older, younger, and smaller females in the commercially important eastern Bering Sea snow crab, *Chionoecetes opilio*. The objective of this study was to investigate patterns of variability in embro quality, which could bias egg production-based indices of reproductive potential. Embryo diameter, mean embryo dry weight, and proximate biochemical composition (% C and % N) did not vary significantly with female size or shell condition, and statistical models including these terms explained a low proportion of the overall variance. These results suggest that embryo quality is generally

conservative and does not vary with female size or shell condition. We also investigated relationships between fecundity and embryo quality by examining the correlation of % C, % N, mean egg weight, and mean embryo diameter with fecundity. In order to remove effects of female size and shell condition, we used residuals of this relationship. The % C, an index of lipid content, was significantly and positively correlated ($r = 0.38$, $p = 0.03$) with residual fecundity. Embryo lipid content may be incrementally greater in females with higher than average fecundity due to differences in female condition (e.g., bottom-up effects). Our analysis suggests that variation in embryo quality is small and unlikely to bias indices of egg production.

Molt-timing and soft-shell handling levels for male Dungeness crabs in Southeast Alaska

Gretchen H. Bishop, ADF&G, Division of Commercial Fisheries, Southeast Region, Douglas, AK

Commercial harvest of Dungeness crabs, *Cancer magister*, in Southeast Alaska began in the 1930s. For the 2009/10 season, they were by far the most valuable shellfish fishery in Southeast Alaska, producing a harvest of 3.57 million lb, with an exvessel value of approximately $5.97 million. Despite the undisputed value of the fishery, the resilient life history of the species has permitted exploitation by a 3-S (size, sex, and season) harvest strategy. However, in Southeast Alaska the season provides only partial protection during sensitive life history periods, as the summer season overlaps the male molt, identified to occur February through July. Managers have had difficulty dealing with this problem due to uncertainty around the spatial and interannual variability in the timing of the male molt and the level of handling in the fishery. To gather more information, several field sampling programs were initiated. Extensive on the grounds sampling was conducted in 1999, a survey was conducted from 2000 through 2004, and the annual dockside sampling program was ramped up with the establishment of spatial and monthly sampling goals in 2001. We report here on the results of these efforts pertaining to male molt timing, and soft shell handling levels in the commercial fishery. We also discuss the ecological, evolutionary, and anthropogenic factors leading to variable life history timing, and the implications of handling soft shell crabs. The summer fishery for Dungeness crab is associated with the catch and handling of recently-molted, sublegal males, and females and rates of leg loss are consistent across these groups. High rates of nontarget catch and limb loss are likely to have some impact on stock productivity.

Tanner crab, *Chionoecetes bairdi*, tagging in the Kodiak District, 2004–2010

Kally Spalinger, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, AK

Understanding the movement dynamics of crab stocks can be important to fishery management. Setting harvest limits based on the abundance of crab observed in stock assessment surveys may be biased if substantial exchange of harvestable crab occurs between the geographic districts during the interval between the survey and the fishery. Large male Tanner crab were tagged during stock assessment surveys on the northeast and eastside of Kodiak Island to evaluate variability in harvest rates among areas and determine if crab were more or less likely to be harvested in the same area in which they were tagged. Harvest and tag recovery rates varied between areas. Estimated harvest rates were higher among areas with high tag recovery rates but trends could be affected by concentration of fishing effort. Most recovered crab moved from summer to winter and tended to move from inshore to offshore, or stay offshore. These results suggest that managers can reasonably limit harvest in nearshore waters based on results of the summer survey since movement of harvestable crab into nearshore waters is limited.

Alaska Fisheries Science Center—Crab research overview

Bob Foy, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK

Researchers at the NMFS Kodiak Lab (KL) are involved in diverse research projects with a common focus on the assessment, biology, and ecology of commercially important crabs stocks in Alaska. A primary focus of KL personnel is the eastern Bering Sea trawl survey which collects abundance, distribution, and biological information which supports the stock assessment of all Eastern Bering Sea crab stocks. The time-series of crab data from the eastern Bering Sea is also maintained, verified, and extensively reviewed for data quality at the KL. Factors influencing crab mortality are an important area of research with projects focused on snow and Dungeness crab handling mortality and mortality due to ghost fishing by derelict pot gear. Research on crab biology and ecology at KL includes studies of the effects of ocean acidification on commercially important crabs at various life stages, habitat association/preference of juvenile crab, incidence and effects of disease, crab reproduction, and mass larval culture. Important outcomes of this research include observations of 10% to 37% annual mortality for red king crab *in situ* in Women's Bay due to derelict crab pots, decreased survival and growth of larval king and Tanner crab under acidic conditions, and complex roles of habitat in mediating survival of juvenile king crabs.

Red king crab population in southeast Alaska: Evaluation of three independent biomass estimates

Chris Siddon, ADF&G, Division of Commercial Fisheries, Southeast Region, Douglas, AK

Pot surveys for red king crab occur in nine spatially discrete locations in the fjord system of Southeast Alaska, which account for 70% of historical catch. Region-wide estimates of mature male biomass for based on catch-survey analysis (CSA) have declined by over one-half from in the past 20 years with no apparent response to fishery closures. Changes in crab distribution or movement relative to spatially static survey areas could bias estimates of biomass. A cooperative research project between ADF&G and the commercial fleet, jointly funded by industry, North Pacific Research Board, and ADF&G, is underway to derive independent estimates of abundance in the surveyed areas based on depletion and mark–recapture for comparison with the catch-survey analysis method. The study is complete in three areas with five more to complete. Preliminary results show wide variation in abundance estimates among methods within survey areas. Abundance estimated from CSA was intermediate to estimates based on depletion and mark–recapture in one survey area, while the mark–recapture estimate of abundance was five times greater than the CSA estimate in another area. These results suggest that the performance of the abundance estimation method may vary substantially among survey areas. Upon completion the results of this study will be used to evaluate the effectiveness of the current method of biomass estimation and recommendations developed for integration into fishery management.

Red king crab movement, growth, and size composition within eastern Norton Sound, 2012–2015

Jenefer Bell, ADF&G, Commercial Fisheries Division, Arctic-Yukon-Kuskokwim Region, Nome, AK

Norton Sound red king crab are targeted by subsistence and commercial fisheries in both the summer and winter with the primary harvest occurring in the summer commercial fishery. The stock is surveyed triennially by a trawl survey and by limited through-the-ice pot sampling in the winter. The spatial distribution of harvest has shifted eastward since the 1990s and there is concern that an unknown proportion of the harvest may not be accounted for in surveys due to spatial mismatch between crab distributions and the surveyed area. Limited information is also available

on a number of critical life history parameters. A tag–recapture and pot survey study design funded by the North Pacific Research Board has been developed to address some of these questions. The study objectives are to 1) improve understanding of onshore-offshore movements, 2) examine biological data on growth and reproduction, 3) identify female molting/mating locations, 4) estimate growth increments, and 5) estimate discard rates.

Review of genetic studies of red king crabs

W. Stewart Grant, ADF&G, Gene Conservation Laboratory, Anchorage, AK

David Tallmon, UAS, Department of Biology, Juneau, AK

Beginning in the 1980s, several molecular markers have been used to understand not only the stock structure of red king crab populations, but several aspects of red king crab biology. Allozyme, mitochondrial (mt) DNA, single nucleotide polymorphisms, and microsatellite markers are largely consistent in defining three major genetic lineages across the North Pacific: 1) Asian populations (including those in the western Aleutians and Norton Sound), 2) Bristol Bay and eastern Gulf of Alaska, and 3) Southeast Alaska. Bayesian skyline plots of mtDNA sequences show a postglacial episode of population growth that followed the retreat of terrestrial glaciers from marine areas about 11,000 years ago. A strong gradient in mtDNA and microsatellite diversity occurs among populations across the North Pacific with greatly diminished genetic diversities in Southeast Alaska populations. Populations along the western Aleutian Island and in Norton Sound differ significantly from those in the southeastern Bering Sea. The analysis of allele and haplotype frequencies shows little differentiation among populations from Bristol Bay to Kachemak Bay, but considerable genetic differentiation occurs between fjord populations in Southeast Alaska. Significant microsatellite allele frequency shifts over generations were also found in some of the fjord populations of Southeast Alaska, indicating that these populations are small and are influenced by random genetic drift. Microsatellite markers in the offspring of 12 egg clutches indicated that female crabs mated with only one male. The results of these studies largely confirm the present subdivision of red king crab populations into several harvest registration areas as a conservative approach to fisheries management. The low genetic diversity and fragmentation among populations in Southeast Alaska indicate that these populations may be vulnerable to local extinctions should be managed cautiously.

Cook Inlet area Tanner crab fishery status

Elisa Russ, ADF&G, Division of Commercial Fisheries, Central Region, Homer, AK

Commercial Tanner crab fisheries in lower Cook Inlet have been closed since the mid-1990s with limited signs of recovery since closure. However, noncommercial (subsistence, sport, and personal use) fishery openings have continued intermittently due to lower abundance thresholds for opening. A bag limit of five male Tanner crab per day applies to all noncommercial fisheries along with season and gear restrictions. Noncommercial harvests in Kachemak Bay exceeded the associated guideline harvest level (determined from trawl survey estimates of abundance) in 2008/9 and 2009/10 but underperformed in 2010/11. The fishery was closed midseason by executive order in 2011/12 due to very poor catches relative to effort. Noncommercial harvest was very low (<8% of the guideline harvest level) in the Kamishak Bay district. A challenge to the management of the noncommercial fishery has been the very high levels of effort inside Kachemak Bay, adjacent to Homer, relative to other areas.

Preliminary results of the 2011 Pribilof district red and blue king crab pot survey

Vicki Vanek, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, AK

The Pribilof Islands District has been surveyed triennially since 2003 to evaluate the distribution and relative abundance and gather biological information for red and blue king crabs. Sampling stations are located on a 5 nm grid with four 7′ × 7′ rectangular pots set at each stations. In 2011 the surveyed area was generally between and to the northeast of St. Paul and St. George Islands covering areas of high historic catch of blue king crab. Pot survey sampling occurs at high spatial density than the standard trawl survey. Pot survey results indicated that blue king crab were more broadly distributed than red king crab within the survey area but legal size male red king crab were distributed in close proximity to blue king crab. The survey also catches large numbers of *Chionoecetes bairdi* and *C. opilio* and provides distribution and biological information for these commercially important species within the survey area.

Crab pot CPUE: a mumble thinking

Jie Zheng and Shareef Siddeek, ADF&G, Division of Commercial Fisheries, Juneau, AK

Proportionality between CPUE and abundance is a very useful assumption for stock assessment and fisheries management but in practice clear relationships have been difficult to demonstrate. If crab catchability (q) changes as a function of population size or some other time varying function then CPUE may not be a robust index of population size. Estimates of catchability are likely more reliable for eastern Bering Sea Tanner crab and Bristol Bay red king crab than for eastern Bering Sea snow crab, but estimated catchability varied with time for all stocks. For Aleutian Islands golden king crab stocks catchability appears to have increased with fishery rationalization after 2005. A number of models have been proposed to standardize pot CPUE based on relationships between catch and soak time. Standardization improves the stability of catchability estimates for golden king crab but substantial differences in soak time among time periods in the fishery complicate comparisons. For Norton Sound red king crab a variety of factors including differences among vessels, time periods within seasons, and environmental indices were not clearly associated with temporal variation in CPUE. Instead a running-average may be suitable approach to standardizing data for this stock. Improved techniques of CPUE standardization are an important research objective for Bering Sea/Aleutian Islands crab stocks.

POSTER PRESENTATIONS

1. Spatiotemporal variability in simulated advection patterns of larval Tanner crab in the eastern Bering Sea
   Jon Richar, UAF, School of Fisheries and Ocean Sciences, Juneau, Alaska.
2. Mass molting of Tanner crab, *Chionoecetes bairdi*, in the Kodiak Archipelago
   Laura Slater, ADF&G, Division of Commercial Fisheries, Westward Region, Kodiak, Alaska.
3. Does maternal size affect red king crab recruitment potential due to embryo or larval production?
   Katherine Swiney, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, Alaska.
4. Movement of *Paralithodes brevipes* into the Bering Strait and Norton Sound Area
   Wes Jones, Norton Sound Economic Development Corporation, Unalakleet, Alaska.

PLANS FOR 2012

The annual Alaskan crab research meetings continue to be productive and valuable for free exchange of scientific results, ideas, and perspectives. A 17th annual meeting is expected to be scheduled for the approximate dates of December 15–17, 2012 in Kodiak, Alaska.

PROPOSALS FOR NEXT YEAR'S SPECIAL TOPIC

1. Effectiveness of slot limits for management of crustacean fisheries.
2. Effects of size-selective harvest on crab reproduction and recruitment.
3. Ecosystem-based management and application to crab fisheries.
4. New developments in harvest strategies for crustacean fisheries.

ACKNOWLEDGEMENTS

The authors thank the presenters for providing us with electronic copies of their slide presentations, allowing us to faithfully summarize the material presented. The author of this report accepts responsibility for errors in interpretation.

APPENDICES

Appendix A.–List of participants at the 2011 Interagency Crab Research Meeting.

Last Name	First Name	Affiliation	Location	Email
Alinsunurin	Rachel	ADF&G	Dutch Harbor	rachel.alinsunurin@alaska.gov
Baechler	Britta	ADF&G	Dutch Harbor	britta.baechler@alaska.gov
Baer	Rob	ADF&G	Kodiak	robert.baer@alaska.gov
Barnard	David	ADF&G	Kodiak	david.barnard@alaska.gov
Bishop	Gretchen	ADF&G	Douglas	gretchen.bishop@alaska.gov
Bell	Jenefer	ADF&G	Nome	jenefer.bell@alaska.gov
Burt	Ryan	ADF&G	Dutch Harbor	ryan.burt@alaska.gov
Bush	Karla	ADF&G	Douglas	karla.bush@alaska.gov
Daly	Ben	UAF	Seward	ben.daly@alaska.edu
Descoteaux	Raphaelle	UAF	Fairbanks	rdescoteaux@alaska.edu
Donaldson	Wayne	ADF&G	Kodiak	wayne.donaldson@alaska.gov
Eckert	Ginny	UAF	Juneau	ginny.eckert@uaf.edu
Ellsworth	Aaren	ADF&G	Kodiak	aaren.ellsworth@alaska.gov
Evans	Eric	ADF&G	Dutch Harbor	eric.evans@alaska.gov
Fitch	Heather	ADF&G	Dutch Harbor	heather.barnhart@alaska.gov
Foy	Bob	NMFS	Kodiak	robert.foy@noaa.gov
Gaeuman	Bill	ADF&G	Kodiak	william.gaueman@alaska.gov
Grant	Stewart	ADF&G	Anchorage	william.grant@alaska.gov
Gustafson	Rich	ADF&G	Homer	rich.gustafson@alaska.gov
Hardy	Sarah	UAF	Fairbanks	sarah.hardy@alaska.edu
Hamazaki	Hamachan	ADF&G	Anchorage	toshihide.hamazaki@alaska.gov
Harthill	Trent	ADF&G	Dutch Harbor	trent.harthill@alaska.gov
Henry	Ed	ADF&G	Dutch Harbor	edward.henry@alaska.gov
Honnold	Steve	ADF&G	Kodiak	steve.honnold@alaska.gov
Hulbert	Lee	ADF&G	Juneau	lee.hubert@alaska.gov
Jones	Wes	NSEDC	Nome	wes.jones@nsedc.com
Kent	Scott	ADF&G	Nome	scott.kent@alaska.gov
Keith	Kevin	NSEDC	Nome	kevin@nsedc.com
Lean	Charlie	NSEDC	Nome	charlie.lean@nsedc.com
Messmer	Adam	ADF&G	Douglas	adam.messmer@alaska.gov
Nelson	Russ	NMFS	Seattle	russ.nelson@noaa.gov
Pengilly	Doug	ADF&G	Kodiak	doug.pengilly@alaska.gov
Olson	Andrew	ADF&G	Douglas	andrew.olson@alaska.gov
Pengilly	Doug	ADF&G	Kodiak	doug.pengilly@alaska.gov
Russ	Elisa	ADF&G	Homer	elisa.russ@alaska.gov
Sagalkin	Nick	ADF&G	Kodiak	nick.sagalkin@noaa.gov
Schwenzfeier	Mary	ADF&G	Dutch Harbor	mary.schwenzfeier@alaska.gov
Shepard	Ric	ADF&G	Kodiak	ric.shepard@alaska.gov
Siddeek	M.S.M.	ADF&G	Juneau	shareef.siddeek@alaska.gov
Siddon	Chris	ADF&G	Juneau	chris.siddon@alaska.gov
Smith	Quinn	ADF&G	Douglas	quinn.smith@alaska.gov

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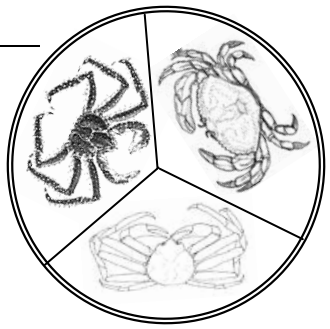
Last Name	First Name	Affiliation	Location	Email
Spalinger	Kally	ADF&G	Kodiak	kally.spalinger@alaska.gov
Stephan	Jeff	UFMA	Kodiak	jstephan@ptialaska.net
Stichert	Laura	ADF&G	Kodiak	laura.stichert@alaska.gov
Stichert	Mark	ADF&G	Kodiak	mark.stichert@alaska.gov
Tamone	Sherry	UAS/UAF	Juneau	sherry.tamone@uas.alaska.edu
Trowbridge	Charlie	ADF&G	Homer	charlie.trowbridge@alaska.gov
Tschersich	Philip	ADF&G	Kodiak	philip.tschersich@alaska.gov
Urban	Dan	NMFS	Kodiak	dan.urban@noaa.gov
Vanek	Vicki	ADF&G	Kodiak	vicki.vanek@alaska.gov
Webb	Joel	ADF&G	Juneau	joel.webb@alaska.gov
Wessel	Maria	ADF&G	Cordova	maria.wessel@alaska.gov
Woodby	Doug	ADF&G	Juneau	doug.woodby@alaska.gov
Worton	Carrie	ADF&G	Kodiak	carrie.worton@alaska.gov
Zaleski	Molly	UAF	Juneau	mfox30@alaska.edu
Zheng	Jie	ADF&G	Juneau	jie.zheng@alaska.gov



Interagency Crab Research Meeting
December 14-16th, 2011

All sessions will be held in the Endeavour Room (downstairs from the lobby) at the Hotel Captain Cook.

WEDNESDAY, DECEMBER 14
Afternoon Session: 1:00–4:30 p.m.

I. Introductions
II. Opening remarks: Doug Woodby, Russ Nelson
III. Meeting agenda: Modify and Adopt
IV. Future plans for the Interagency Crab Meeting
V. Research Review

A. University of Alaska

1. The role of eyestalk hormones in regulating metabolic physiology in crabs
   Sherry Tamone, UAS, Juneau, AK

2. Updates on bycatch mortality studies
   Dan Urban, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK

3. Predicting the distribution and ecological niche of unexploited snow crab (*Chionoecetes opilio*) populations in Alaskan waters: A first open-access ensemble model
   Sarah Hardy, UAF, School of Fisheries and Ocean Sciences, Fairbanks, AK

4. Methyl farnesoate in *Chionoecetes opilio*: not your everyday gonadotropic hormone!
   Molly Zaleski, UAF, School of Fisheries and Ocean Sciences, Juneau, AK

Coffee: Mid-Afternoon (15 minutes)

5. *In situ* predation and behavioral plasticity of juvenile red king crabs (*Paralithodes camtschaticus*)
   Ben Daly, UAF, School of Fisheries and Ocean Sciences, Seward, AK

6. Effects of ocean acidification on larval development of Dungeness crabs
   Raphaelle Descoteaux, UAF, School of Fisheries and Ocean Sciences, Fairbanks, AK

7. Are all created equal? Variation in snow crab egg quality
   Joel Webb, UAF, School of Fisheries and Ocean Sciences, Juneau, AK

B. Alaska Department of Fish and Game

1. Molt timing and soft shell handling levels for male Dungeness crabs in Southeast Alaska
   Gretchen Bishop, ADF&G, Douglas, AK

2. Tanner crab (*Chionoecetes bairdi*) tagging in the Kodiak Management District, 2004–2010
   Kally Spalinger, ADF&G, Kodiak, AK

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THURSDAY, DECEMBER 15
8:00 – 8:30 a.m. Coffee
Morning Session: 8:30 a.m.–12:00 p.m.

C. Special Topic: Crab surveys in Alaska—Current and future practice
1. From sensors to platforms, from data to information—How technology can help in benthic surveys for fisheries related activities (45 min.)
Hanumant Singh, Woods Hole Oceanographic Institution, Woods Hole, MA
2. Alaska Fisheries Science Center Annual Eastern Bering Sea Bottom Trawl Survey
Bob Foy, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK

Coffee: Mid-Morning (15 minutes)

3. Norton Sound area crab surveys
Hamachan Hamazaki, ADF&G, Anchorage, AK
4. Southeast region crab surveys
Gretchen Bishop, ADF&G, Douglas, AK
5. Central region crab surveys
Rich Gustafson, ADF&G, Homer, AK
6. Westward region crab surveys
Kally Spalinger, Carrie Worton, et al., ADF&G, Kodiak, AK
7. Discussion (30 min.)

Lunch: 12:00 –1:30 p.m.
Afternoon Session: 1:30–2:30 p.m.

D. National Marine Fisheries Service
1. Alaska Fisheries Science Center crab research overview (30 min.)
Bob Foy, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK
2. Hybrid Chionoecetes, What we know and what we don't know
Dan Urban, NMFS, Alaska Fisheries Science Center, Kodiak Laboratory, Kodiak, AK

Poster Session and Mid-Afternoon Coffee: 2:30–3:30 p.m.
Afternoon Session (continued): 3:30–4:30 p.m.

E. Alaska Department of Fish and Game (continued)
1. Red king crab populations in Southeast Alaska: Evaluation of three independent biomass estimates
Chris Siddon, ADF&G, Douglas, AK
2. Red king crab movement, growth, and size composition within eastern Norton Sound, 2012–2015
Jenefer Bell, ADF&G, Nome, AK
3. Update on the phylogeography of red king crabs
Stew Grant, ADF&G, Anchorage, AK
4. Cook Inlet area Tanner crab fishery status
Elisa Russ, ADF&G, Homer, AK

-continued-

Reservations for dinner at the Glacier Brewhouse for groups of ten at 5:15 p.m. and 6:15 p.m.

FRIDAY, DECEMBER 16

8:00–8:30 a.m. Coffee

Morning Session: 8:30–11:00 a.m.

F. Alaska Department of Fish and Game (continued)
   1. The 2011Pribilof Islands king crab pot survey
      Vicki Vanek, ADF&G, Kodiak, AK
   2. Westward region update
      Doug Pengilly, ADF&G, Kodiak, AK
   3. Crab pot CPUE: a mumble thinking
      Jie Zheng and Shareef Siddeek, ADF&G, Juneau, AK

VI. Next Year's Meeting and Special Topic Suggestions

VII. Other Business

VIII. Poster Presentations
   1. Spatiotemporal variability in simulated advection patterns of larval Tanner crab in the eastern Bering Sea
      Jon Richar, UAF, School of Fisheries and Ocean Sciences, Fairbanks, AK
   2. Mass molting of Tanner crab, *Chionoecetes bairdi*, in the Kodiak Archipelago
      Laura Slater, ADF&G, Kodiak, AK
   3. Does maternal size affect red king crab recruitment potential due to embryo or larval production?
      Katherine Swiney, NMFS, Alaska Fisheries Science Center, Kodiak, AK
   4. Movement of *Paralithodes brevipes* into the Bering Strait and Norton Sound Area
      Wes Jones, Norton Sound Economic Development Corporation, Unalakleet, AK